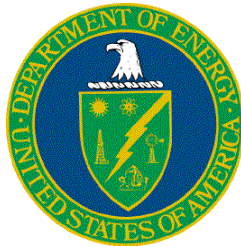**Defense Nuclear Facilities Safety Board Recommendation 2002-1
Software Quality Assurance Implementation Plan
Commitment 4.2.1.3:**

GENII Gap Analysis

Interim Report

U.S. Department of Energy
Office of Environment, Safety, and Health
1000 Independence Ave., S.W.
Washington, DC 20585-2040

January 2004

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FOREWORD

This document provides an evaluation of the Software Quality Assurance (SQA) attributes of the radiological dispersion computer code, GENII, relative to established requirements. The evaluation, a "gap analysis", is performed to meet commitment 4.2.1.3 of the Department of Energy's Implementation Plan to resolve SQA issues identified in the Defense Nuclear Facilities Safety Board Recommendation 2002-1. Both versions of the GENII code (1.485 and 2.0) are addressed.

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REVISION STATUS

Page/Section	Revision	Change
1. Entire Document	1. Interim Report	1. Original Issue

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Software Quality Assurance Implementation Plan:
GENII Gap Analysis

EXECUTIVE SUMMARY

The Defense Nuclear Facilities Safety Board (DNFSB) issued Recommendation 2002-1 on *Quality Assurance for Safety-Related Software* in September 2002 (DNFSB 2002). The Recommendation identified a number of quality assurance issues for software used in the Department of Energy (DOE) facilities for analyzing hazards and designing and operating controls that prevent or mitigate potential accidents. The development and maintenance of a collection, or "toolbox," of high-use, Software Quality Assurance (SQA)-compliant safety analysis codes is one of the major commitments contained in the February 28, 2003 *Implementation Plan for Recommendation 2002-1 on Quality Assurance for Safety Software at Department of Energy Nuclear Facilities* (DOE 2003a). A DOE safety analysis toolbox would contain a set of appropriately quality-assured, configuration-controlled, safety analysis codes, managed, and maintained for DOE-broad safety basis applications.

DOE has designated six computer codes for toolbox consideration. All six are accident and consequence analysis software, and include the following:

Fire Source Term:	CFAST
Leak Path Factor:	MELCOR
Chemical Release/Dispersion and Consequence:	ALOHA, EPIcode
Radiological Dispersion and Consequence:	MACCS2, GENII.

Each of the codes designated for the toolbox may require some degree of quality assurance improvement before meeting current SQA standards. In the interim period before these changes are completed, the designated toolbox codes are considered useful assets in the support of safety basis calculations. To determine the actions needed to bring the codes into compliance with the SQA qualification criteria and develop a schedule with milestones to upgrade each code based on the gap analysis results, the Implementation Plan has committed to sponsoring a set of code-specific gap analysis documents. Gap analysis evaluates each code's SQA attributes against identified criteria.

The balance of this document provides the GENII gap analysis documentation. Both versions of GENII, 1.485 and 2.0, have been evaluated. For GENII 1.485, of the ten general topical quality areas that were evaluated for software developers, nine met the criteria fully, and one failed to meet the criteria. For GENII 2.0, of the ten general topical quality areas, two met the criteria fully, five met the criteria partially, and three failed to meet the criteria. Recommendations are given for each of the topical areas in Section 4.0. The GENII code was evaluated to determine if the code, as it currently stands, meets the intended function for the code in the context as described in the scope of this gap analysis. When the code is run for the intended applications, as detailed in the code guidance document, *Computer Code Application Guidance for Documented Safety Analysis*,

(DOE 2003f), it is judged that GENII 1.485 will meet its intended function, but GENII 2.0 will not. Therefore, only GENII 1.485 can be recommended for DSA use at this time.

It is estimated that approximately ten full-time equivalent (FTE) months would be required to perform all SQA upgrade tasks identified in Section 4.0 of this report.

While completion of the GENII 2.0 development is encouraged, current DOE DSA support should be through the earlier code version, GENII 1.485. No evidence was found of software-induced errors in GENII 1.485 that have led to non-conservatisms in nuclear facility operations or in the identification of facility controls.

1.0   Introduction

This document reports on the results of a gap analysis for the GENII computer code. Both versions of the code (1.485 and 2.0) are considered.

The intent of the gap analysis is to determine the actions needed to bring the toolbox codes into compliance with the SQA qualification criteria and develop a schedule with milestones to upgrade each code based on the gap analysis results. Gap analysis evaluates each code's SQA attributes against identified criteria.

1.1   Background: Overview of Designated Toolbox Software
      in the Context of 10 CFR 830

The DNFSB issued Recommendation 2002-1 on *Quality Assurance for Safety-Related Software* in September 2002. The Recommendation identified a number of quality assurance issues for software used in the DOE facilities for analyzing hazards, and designing and operating controls that prevent or mitigate potential accidents. The development and maintenance of a collection, or "toolbox," of high-use, SQA-compliant safety analysis codes is one of the major commitments contained in the March 2003 *Implementation Plan for Recommendation 2002-1 on Quality Assurance for Safety Software at Department of Energy Nuclear Facilities*. In time, the DOE safety analysis toolbox will contain a set of appropriately quality-assured, configuration-controlled, safety analysis codes, managed and maintained for DOE-broad safety basis applications.

Six computer codes, including ALOHA (chemical release dispersion/consequence analysis), CFAST (fire analysis), EPIcode (chemical release dispersion/consequence analysis), GENII (radiological dispersion/consequence analysis), MACCS2 (radiological dispersion/consequence analysis), and MELCOR (leak path factor analysis), were designated by DOE for the toolbox (DOE/EH, 2003). It is found that these codes provide generally recognized and acceptable approaches for modeling source term and consequence phenomenology, and can be applied as appropriate to support accident analysis in Documented Safety Analyses (DSAs).

As one of the designated toolbox codes, GENII, will likely require some degree of quality assurance improvement before meeting current SQA standards. The analysis documented herein is an evaluation of GENII, both versions 1.485 and 2.0, relative to current software quality assurance criteria. It assesses the margin of the deficiencies, or gaps, to provide DOE and the software developer the extent to which minimum upgrades are needed. The overall assessment is therefore termed a "gap" analysis.

1.2 Evaluation of Toolbox Codes

The quality assurance criteria identified in later sections of this report are defined as the set of established requirements, or bases, by which to evaluate each designated toolbox code. This gap analysis evaluation, is commitment 4.2.1.3 in the IP:

> Perform a SQA evaluation to the toolbox codes to determine the actions needed to bring the codes into compliance with the SQA qualification criteria, and develop a schedule with milestones to upgrade each code based on the SQA evaluation results.

This process is a prerequisite step for software improvement. It will allow DOE to determine the current limitations and vulnerabilities of each code as well as help define and prioritize the steps required for improvement.

Ideally, each toolbox code owner will provide input information on the SQA programs, processes, and procedures used to develop their software. However, the gap analysis itself will be performed by a SQA evaluator. The SQA evaluator is independent of the code developer, but knowledgeable in the use of the software for accident analysis applications and current software development standards.

1.3 Uses of the Gap Analysis

The gap analysis will provide information to DOE, code developers, and code users.

DOE will see the following benefits:
- ? Estimates of the resources required to perform modifications to designated toolbox codes
- ? Basis for schedule and prioritization to upgrade each designated toolbox code.

Each code developer will be provided:
- ? Information on areas where software quality assurance improvements are needed to comply with industry SQA standards and practices
- ? Specific areas for improvement for guiding development of new versions of the software.

DOE safety analysts and code users will benefit from:
- ? Improved awareness of the strengths, limits, and vulnerable areas of each computer code
- ? Recommendations for code use in safety analysis application areas.

1.4 Scope

This analysis is applicable to the GENII code, one of the six designated toolbox codes for safety analysis (Table 1-1). While GENII is the subject of the current report, other safety analysis software considered for the toolbox in the future may be evaluated with the same process applied here. The template outlined in this document is applicable to analytical software as long as the primary criteria are ASME NQA-1, 10 CFR 830, and related DOE directives discussed in DOE (2003e).

Table 1-1 — Software Designated for DOE Safety Analysis Toolbox

Code	Version or Revision
ALOHA	5.2.3
CFAST	3.1.6
EPIcode	7.0
GENII	1.485 and 2.0[1]
MACCS2	1.12[2]
MELCOR	1.8.5

1.5   Purpose

The purpose of this report is to document the gap analysis performed on the GENII code as part of DOE's implementation plan on SQA improvements.

1.6   Methodology for Gap Analysis

The gap analysis for GENII is based on the criteria as described in *Software Quality Assurance Plan and Criteria for the Safety Analysis Toolbox Codes* (DOE 2003e). In it, Table 3-2 lays out fourteen topical areas related to code quality assurance. The gap analysis as reported here utilizes ten of the fourteen areas to assess the quality of the GENII code. The ten areas are pertinent to software development, while the four not assessed are judged more applicable to software end user organizations or to different categories of software than is the subject of the current study. Section 4.0 gives the detail of each analysis for each of the ten areas in Subsections 4.1 to 4.10.

In general, fourteen requirement areas demonstrate compliance with NQA-1 2000. They are as follows:

1) Software Classification
2) SQA Procedures/Plans
3) Dedication
4) Evaluation

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[1] In the interim period before quality assurance improvements are made to version 2.0 of GENII, version 1.485 is recommended.

[2] In the interim period before quality assurance improvements are made to MACCS2, either MACCS2 or its predecessor MACCS (version 1.5.11.1) may be applied to DSAs.

5) Requirements
6) Design
7) Implementation
8) Testing
9) User Instructions
10) Acceptance Test
11) Operation and Maintenance
12) Configuration Control
13) Error Impact
14) Access Control

Table 3-1 of *Software Quality Assurance Plan and Criteria for the Safety Analysis Toolbox Codes* (DOE 2003e)[3] provides the required versus graded breakdown per area for Class B software that is *existing* or *purchased* as well.

The gap analysis utilizes ten of the fourteen topical areas listed in DOE (2003e) related to SQA to assess the quality of the GENII code. The four areas eliminated in this gap analysis are dedication, evaluation, operation and maintenance, and access control. These areas focus on software intended to control hardware or focus on the end user SQA for the software. Therefore, the remaining ten areas are assessed individually in Section 4.

Each of the areas is broken down into one or more specific criteria. The requirements, as listed in Table 3-2 of the DOE SQA plan under the column 'software developer,' are refined, extracted, and listed separately in the tables that follow. NQA-1 2000 wording found in Table C-1 of the DOE SQA plan also aids this individual criterion development. Effort is made to preserve the exact wording of the requirements as much as possible.

No unique methodology related to the GENII was involved in this gap analysis.

1.7   Summary Description of Software Being Reviewed

The gap analysis was performed on both versions of the GENII code (i.e., Version 1.485 [Napier, 1988a, 1988b, 1988c] and Version 2.0 [Napier, 1995, 2002a, 2002b, 2003]). Although the earlier version (1.485) is the one recommended for use in current DSAs, the later version (2.0) is also evaluated, because the improvements recommended here, if implemented, would allow it to be used in DSAs in the future. In the following discussion, RSICC refers to the Radiation Safety Information Computational Center at Oak Ridge, TN.

The set of documents reviewed as part of the gap analysis are listed in Table 1-2.

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[3] In the following discussion, this document (DOE, 2003e) is cited as "the DOE SQA plan."

Table 1-2 — Software Documentation Reviewed for GENII

No.	Information	
1.	Reference:	B. A. Napier, R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, *GENII – The Hanford Environmental Radiation Dosimetry Software System. Volume 1: Conceptual Representation.* PNL-6584, December 1988. (Napier, 1988a)
	Remarks:	Documentation provided by RSICC in .pdf format
2.	Reference:	B. A. Napier, R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, *GENII – The Hanford Environmental Radiation Dosimetry Software System. Volume 2: User's Manual,* PNL-6584, November 1988. (Napier, 1988b)
	Remarks:	Documentation provided by RSICC in .pdf format
3.	Reference:	B. A. Napier, R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, *GENII – The Hanford Environmental Radiation Dosimetry Software System. Volume 3: Code Maintenance Manual,* PNL-6584, September 1988. (Napier, 1988c) Only the table of contents is available (included as part of the .pdf file of Volumes 1 and 2). Bruce Napier has one of the few copies of the entire document (Volume 3), which is about 1,500 pages long, but a copy was not available for this gap analysis.
	Remarks:	Table of contents in .pdf format provided by RSICC.
4.	Reference:	B. A. Napier, J. V. Ramsdell, and D. L. Strenge, *Software Requirements Specifications for Hanford Environmental Dosimetry Coordination Project*, Draft Report, prepared for review by the EPA Office of Radiation and Indoor Air, May 1995. (Napier, 1995)
	Remarks:	Documentation provided by Bruce Napier.
5.	Reference:	B. A. Napier, *GENII Version 2 User's Guide* (Napier, 2002a)
	Remarks:	Downloaded from PNNL website

No.	Information	
6.	Reference:	B. A. Napier, D. L. Strenge, J. V. Ramsdell, Jr., P. W. Eslinger, and C. Fosmire, *GENII Version 2 Software Design Document* (Napier, 2002b)
	Remarks:	Downloaded from PNNL website
7.	Reference:	B. A. Napier, *GENII Version 2 Example Calculation Descriptions* (Napier, 1999a)
	Remarks:	Documentation on CD from EFCOG training class, June 1999
8.	Reference:	B. A. Napier and L. Staven, *GENII Version 2 Training Power Point Slides* (Napier, 1999b)
	Remarks:	Documentation on CD from EFCOG training class, June 1999
9.	Reference:	B. A. Napier, *Getting Started with GENII Version 2* (Napier, 2003)
	Remarks:	Downloaded from EPA/NESHAPs website
10.	Reference:	B. A. Napier, E-mail communications with K. R. O'Kula and Vern Peterson
	Remarks:	Provided in Appendix A
11.	Reference:	W. E. Joyce, Telephone conversation with V. L. Peterson
	Remarks:	Provided in Appendix A
12.	Reference:	Publications supporting GENII Benchmarking and V&V
	Remarks:	Provided in Appendix B

2.0   Assessment Summary Results

2.1   Criteria Met

For GENII 1.485, of the applicable ten general topical quality areas, nine met the criteria fully, and one failed to meet the criteria. An exception was found in the area of Error Impact. GENII 1.485 should create and follow a formal error reporting and corrective action process. For GENII 2.0, of the ten general topical quality areas, two met the criteria fully, five met the criteria partially, and three failed to meet the criteria. Exceptions were found in the areas of Testing Phase, Acceptance Test, Error Impact, and partially in the areas of SQA Procedures and Plans, Requirements Phase, Design Phase, Implementation Phase, and User Instructions.

2.2   Exceptions to Criteria

Some of the more important exceptions to criteria found are listed below in Table 2-1 for GENII 2.0. No similar list is needed for GENII 1.485. The criterion is given; the reason the criterion was judged not to be met is specified and action needed to remedy the exception is suggested.

Table 2-1 — Summary of Important Exceptions, Reasoning, and Suggested Remediation for GENII 2.0

No.	Criterion	Reason Not Met	Suggested remedial action(s)
1.	Testing Phase	Testing not yet complete	Document all testing of GENII 2.0
2.	Acceptance Test	Testing not yet complete	Develop and document acceptance criteria for GENII 2.0 and document acceptance testing.
4.	Error Impact	A formal error reporting and corrective action procedure is not followed.	Create and follow a formal error reporting and corrective action process (applies to GENII 1.485 as well)

2.3   Areas Needing Improvement

The gap analysis identified a number of improvements that could be made related to the code and its quality assurance. Some of the important ones are listed in Table 2-2.

Table 2-2 — Summary of Important Recommendations for GENII

No	Recommendation
1.	Establish and follow formal review schedules for GENII 2.0.
2.	Make GENII 2.0 code listings available upon completion and final testing of code.
3.	Correct the user documentation (see Section 4.7.4) and the bugs in the user interface for GENII 2.0 (see Criterion 9.6).
4.	Run a wide variety of scenarios using GENII 1.485 on both DOS and Windows based PCs to verify agreement in results. Memory management is different in Windows than in DOS (under which 1.485 was developed) and there is a potential for problems.
5.	Modify GENII 2.0 to make it easy for the user to determine 95th percentile consequences at the site boundary and at a user-selected collocated worker distance (for example, 100 m).
6.	Assemble the existing "software change packets" for GENII 1.485 into a document to verify that changes to the code followed a logical and verifiable process.

2.4   Areas Not Assessed and Any Limitations of Gap Analysis

All areas were assessed for this gap analysis. Some areas were found to be more difficult to assess than others, depending upon the level of detail provided in the documentation. However, no limitations were imposed on the gap analysis.

2.5   Conclusion Regarding Code's Ability to Meet Intended Function

The GENII code was evaluated to determine if the code, as it currently stands, meets the intended function for the code in the context as described in the scope of this gap analysis. When the code is run for the intended applications, as detailed in the code guidance document, *Computer Code Application Guidance for Documented Safety Analysis*, (DOE 2003f), it is judged that GENII 1.485 will meet its intended function, but GENII 2.0 will not. Therefore, only GENII 1.485 can be recommended for DSA use at this time.

The primary remedial actions required for GENII 2.0 include the following:

(1) Modify the software so that the user can determine the 95th percentile doses at the site boundary in all sectors
(2) Improve the user documentation
(3) Create an error-reporting and corrective action procedure, including its documentation
(4) Complete code testing and document it
(5) Create and implement a code maintenance procedure.

3.0 Lessons Learned

Table 3-1 provides a summary of the lessons learned during the performance of the GENII gap analysis.

Table 3-1 — Lessons Learned

No.	Lesson
1.	Changing criteria in SQA standards over the years can render codes non-compliant that were once compliant.
2.	Although the author of a code may intend the code to be compliant with SQA standards, the standards may present sufficient complexity so that some requirements are not met in total.
3.	Development of software that is compliant with SQA standards can be a costly and laborious endeavor, especially if it is back-fit to the software, instead of being a parallel requirement during software development. If funding for the project is meager, SQA will probably not be followed as closely as may have been intended originally. Completion of the code development may take precedence over SQA measures.
4.	Changing sponsors may impact the SQA pedigree of software. This situation can arise especially if more recent software development was driven by other, non-SQA requirements than were present originally. The current version of the code has been developed for Environmental Protection Agency (EPA)/National Emission Standards for Hazardous Air Pollutants (NESHAPS), while original versions of the code were funded out of the PNNL budget.

4.0   Assessment Detailed Results

Fourteen topical areas are presented. In the tables that follow, sub-criteria and recommendations are labeled as (1.x, 2.x, …, 10.x) with the first value (1., 2., …10) corresponding to the topical area and the second value (x), the sequential table order of each entry.

For both GENII 1.485 (Level B Existing) and GENII 2.0 (Level B Development), ten topical areas were considered. The ten subsections below discuss in detail the evaluation of each of the code versions relative to the ten topical areas.

4.1   Topical Area 1 Assessment: Software Classification

This area corresponds to the requirement entitled *Software Classification* in Table 3-2 of the DOE SQA plan. Because all of the designated toolbox codes are used in applications the results of which are part of an accident analysis evaluation, the most applicable classification is Level B. Level B is further broken down into "Development," "Existing," and "Purchased." Because GENII 1.485 has been in use for many years, it is considered "Level B Existing." However, GENII 2.0 is still in need of further testing and development (as shown below), and is, therefore, classified "Level B development" software.

4.1.1   Criterion Specification and Result

This topical area is "required" for both GENII 1.485 and 2.0. Table 4.1-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.1-1 — Subset of Criteria for Software Classification Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
1.1	The code developer must provide sufficient information to allow the user to make an informed decision on the classification of the software.	Yes for both	The documentation from the developer makes it clear that both GENII 1.485 and 2.0 are Level B software.

4.1.2   Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "Software Classification," except for Item 12 (see Appendix B).

4.1.3   Software Quality-Related Issues or Concerns

There are no other SQA-related issues or concerns in "Software Classification."

4.1.4   Other Areas for Improvement

No areas of improvement in "Software Classification" have been noted.

4.1.5   Recommendations

There are no recommendations related to this Topical Area.

4.2   Topical Area 2 Assessment: SQA Procedures and Plans

This area corresponds to the requirement entitled *SQA Procedures and Plans* in Table 3-2 of the DOE SQA plan (DOE 2003e). It deals with the planning efforts prior to code development.

4.2.1   Criterion Specification and Result

This topical area is "required" for both GENII 1.485 and 2.0. Table 4.2-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.2-1 — Subset of Criteria for SQA Procedures and Plans Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
2.1	Procedures/plans for SQA (SQA Plan) have identified organizations responsible for performing work, independent reviews, etc.	Yes for both	Pacific Northwest National Laboratory (PNNL) (formerly Pacific Northwest Laboratory [PNL]) is responsible for performing the work and providing for independent reviews (Napier, 1988a) and Napier (1995)
2.2	Procedures/plans for SQA (SQA Plan) have identified software engineering methods.	Yes for both	The software engineering methods are discussed in Napier (1988a) and Napier (1995)
2.3	Procedures/plans for SQA (SQA Plan) have identified documentation to be required as part of program.	Yes for both	Required documentation is discussed in Napier (1988a) and Napier (1995)
2.4	Procedures/plans for SQA (SQA Plan) have identified standards, conventions, techniques, and/or methodologies that shall be used to guide the software development, methods to ensure compliance with the same.	Yes for both	The standards, conventions, techniques, and/or methodologies that were used to guide code development are discussed in Napier (1988a) and Napier (1995).
2.5	Procedures/plans for SQA (SQA Plan)	Yes for	Napier (1988a) discusses two

Criterion Number	Criterion Specification	Met?	Summary Remarks
	have identified software reviews and schedule.	1.485. No for 2.0.	formal review periods for GENII 1.485. No similar discussion is in the GENII 2.0 documentation.
2.6	Procedures/plans for SQA (SQA Plan) have identified methods for error reporting and corrective actions.	Yes for 1.485. No for 2.0	Napier (1988b) discusses how to report errors and request upgrades. An informal method is used for GENII 2.0.

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table:

Criterion 2.1 — The GENII 1.485 system was developed under the direction of the DOE office at Hanford for use by nuclear safety analysts. Potential user groups were identified and representatives of these groups were then selected to form a committee to specify the software requirements. Other groups were identified to provide reviews of the design and perform independent testing. The documentation describes these groups by their functions and the names of individual members are given in the "Acknowledgements" section. The organization selected to perform the work was the PNL (now PNNL). The GENII 2.0 system was developed with funding from the EPA. It incorporates much of the code developed for GENII 1.485 but was developed for use by the EPA in Environmental Impact Statements (EISs). The various groups for review and testing are mentioned in Napier (1995), which is the SQA plan for GENII 2.0.

Criterion 2.2 — An appendix to the GENII 1.485 volume 1 (Napier, 1988a) is a detailed system-requirements document. In it, software engineering methods are discussed. For GENII 2.0, the system requirements are given in Napier (1995), which discusses software engineering. (However, the word "engineering" is not used in either document.)

Criterion 2.3 — The GENII 1.485 documentation (Napier, 1988a, 1988b) identified several required documents, including requirements for the overall system, design, implementation, testing, user manual, and maintenance. Likewise, Napier (1995) discusses the planned documentation for GENII 2.0.

Criterion 2.4 — Napier (1988a) and Napier (1995) discuss the standards, conventions, techniques, and/or methodologies to be used to guide code development. Napier (1988a) was prepared, during and after, the development of GENII 1.485 and is, thus, more detailed than Napier (1995), which was prepared before the development of GENII 2.0

Criterion 2.5 — External peer reviews of GENII 1.485 were conducted during the weeks beginning September 14, 1987 and February 1, 1988. This was followed by a formal acceptance of the code upon completion of the documentation packages for the user. Review schedules are not discussed in the GENII 2.0 documentation.

Criterion 2.6 — A formal error-reporting methodology was used for GENII 1.485. A copy of the reporting form is shown in Figure 4-1. For GENII 2.0, error reporting is informal, as evidenced by e-mail from Napier (see Appendix A) that includes the statement "I only have a few beta users; they let me know when it's broke and I fix it for them."


```
PNL SOFTWARE CHANGE PACKET          Change Packet Number   1.

Software Package:     GENII: Hanford Environmental Dosimetry System

Program(s) (indicate):  APPRENTICE  ENVIN    ENV    DOSE
                        INTDF       EXTDF    DITTY

Project title:        Hanford Dose Overview

Project number:       10878

Design document:      Appendix to Part 1 of document.

Document title:       B. A. Napier, R. A. Peloquin, D. L. Strenge, and J.
                      V. Ramsdell. 1988. Hanford Environmental Dosimetry
                      Upgrade Project. GENII - The Hanford Environmental
                      Radiation Dosimetry Software System  Part 1:
                      Conceptual Representation. Part 2: Users Manual.
                                              PNL-6584. Pacific
                      Northwest Laboratory. Richland, WA.

┌ CHANGE(S) REQUESTED AND/OR PROBLEM(S) REPORTED──────
│         (To be completed by person requesting change)
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┌ PROBLEM DOCUMENTATION INCLUDED ──────────────
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└

Submitted by:   _____     Date _____
                Change Requester

Approved by:    _____     Date _____
                PNL GENII Designated Expert

Send to:        B. A. Napier
                Staff Scientist
                Health Physics Department, MS K3-54
                Pacific Northwest Laboratory
                Richland, WA  99352
```

Figure 4-1. Error reporting / update request form for GENII 1.485

4.2.2   Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "SQA Procedures and Plans," except for Item 12 (see Appendix B).

4.2.3   Software Quality-Related Issues or Concerns

Review schedules and a formal error reporting and corrective action methodology needs to be implemented for GENII 2.0.

4.2.4   Other Areas for Improvement

No other areas of improvement are noted.

4.2.5   Recommendations

Recommendations related to this topical area are provide in Table 4.2-2.

Table 4.2-2 — Recommendations for SQA Procedures and Plans Topic

Recom-mendation Number	Relates to Table 4.2-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
2.1	2.6	Implement a Formal Error Report (FER) and handling methodology for GENII 2.0. This is not required for GENII 1.485.	One FTE week	Two weeks
2.2	2.5	Establish formal review schedules for GENII 2.0.	One FTE day	One week

4.3   Topical Area 3 Assessment: Requirements Phase

This area corresponds to the requirement entitled *Requirements* Phase in Table 3-2 of the DOE SQA plan (DOE 2003e).

4.3.1   Criterion Specification and Result

This topical area is "required" for both GENII 1.485 and 2.0. Table 4.3-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.3-1 — Subset of Criteria for Requirements Phase Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
3.1	Software requirements for the subject software have been established.	Yes for both	Software Requirements are in: 1.485: Napier (1988a) appendix 2.0: Napier (1995)
3.2	Software requirements are specified, documented, reviewed, and approved.	Yes for both	1.485: Software specifications, review, and approval are in Napier (1988a) and its appendix. 2.0: Requirements in Napier (1995). Review and approval implied by Napier (2002b).
3.3	Requirements define the functions to be performed by the software and provide detail and information necessary to design the software.	Yes for both	Detailed functional requirements are defined in: 1.485: Napier (1988a) appendix 2.0: Napier (1995)
3.4	A **Software Requirements Document**, or equivalent, defines requirements for functionality, performance, design inputs, design constraints, installation considerations, operating systems (if applicable), and external interfaces necessary to design the software.	Yes for both	Detailed functional requirements are defined in the System Requirements documents: 1.485: Napier (1988a) appendix 2.0: Napier (1995)
3.5	Acceptance criteria are established in the software requirements documentation for each of the identified requirements.	Yes for 1.485. Partial for 2.0	1.485: Napier (1988b, 1988c) 2.0: Acceptance criteria are not specifically described but are implied by testing requirements

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table.

Criteria 3.1 and 3.2 — GENII 1.485 was developed by means of tasks designed to provide a state-of-the-art, technically peer-reviewed, and documented set of programs. The initial task resulted in a system design requirements report, based on input from potential Hanford users, providing general descriptions of the calculations that the final programs must perform. The recommendations of that report formed the basis for the remainder of the tasks, defining the elements that determined the equation formulation and parameter selection tasks (Napier, 1988a). The appendix to that document provides a discussion of SQA issues, including responsible organizations. Napier (1995) provides a similar discussion for GENII 2.0 and states the code was developed in a similar manner. The identified user groups are EPA analysts and contractors.

Criterion 3.5 — Napier (1988b, 1988c) discuss acceptance criteria and testing for GENII 1.485.

The GENII 2.0 documentation does not specifically address acceptance criteria but implies their existence by referring to code testing.

4.3.2 Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "Requirements," except for Item 12 (see Appendix B).

4.3.3 Software Quality-Related Issues or Concerns

The only SQA concern for GENII 2.0 was the lack of specific acceptance criteria. There are no similar concerns for GENII 1.485.

4.3.4 Other Areas for Improvement

No other areas of improvement were noted.

4.3.5 Recommendations

Recommendations related to this topical area are provide in Table 4.3-2.

Table 4.3-2 — Recommendations for Requirements Phase Topic

Recommendation Number	Relates to Table 4.5-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
5.1	5.5	Develop and document acceptance criteria for GENII 2.0.	One FTE week	One month

4.4   Topical Area 4 Assessment: Design Phase

This area corresponds to the requirement entitled *Design Phase* in Table 3-2 of the DOE SQA plan (DOE 2003e).

4.4.1   Criterion Specification and Result

This topical area is "graded" for GENII 1.485 and "required" for GENII 2.0. Table 4.4-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.4-1 — Subset of Criteria for Design Phase Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
4.1	The software design was developed, documented, reviewed, and controlled.	Yes for both	1.485: Napier (1988a) provides System Requirements as well as software design. 2.0: Napier (2002b) is the System Design Document
4.2	Code developer(s) prescribed and documented the design activities to the level of detail necessary to permit the design process to be carried out and to permit verification that the design met requirements.	Yes for both	1.485: Napier (1988a) provides System Requirements as well as software design activities. 2.0: Napier (2002b) is the System Design Document. Pseudo-code listings provided.
4.3	Design presents and documents specification of interfaces, overall structure (control and data flow) and the reduction of the overall structure into physical solutions (algorithms, equations, control logic, and data structures).	Yes for both	1.485: Napier (1988a, b, c) document overall structure, interfaces, control and data flow, and physical solutions. 2.0: Napier (1995, 2002b) document overall structure, interfaces, control and data flow, and physical solutions. Pseudo-code listings are provided. For both, diagrams show the flow of data and logic.

Criterion Number	Criterion Specification	Met?	Summary Remarks
4.4	Design presents and documents that computer programs were designed as an integral part of an overall system. Therefore, evidence should be present that the software design considered the computer program's operating environment.	Yes for both	1.485: Napier (1988ab,c) show that the overall system design accounted for hardware and software interfaces and limitations, including the O/S. 2.0: Napier (1,995, 2002b) provides similar features.
4.5	Design presents and documents that as an integral part of software design, problems are mitigated. These potential problems include external and internal abnormal conditions and events that can affect the computer program.	Yes for 1.485. Partial for 2.0.	1.485: Napier (1988b) provides error-reporting forms to testers and users so that errors can be fixed and users informed. 2.0: the error-reporting is less formal
4.6	A Software Design Document, or equivalent, is available and contains a description of the major components of the software design as they relate to the software requirements.	Yes for both	1.485: Napier (1988a) describes major components of design 2.0: Napier (2002b) is the System Design Document. Pseudo-code listings are provided.
4.7	A Software Design Document, or equivalent, is available and contains a technical description of the software with respect to the theoretical basis, mathematical model, control flow, data flow, control logic, data structure, numerical methods, physical models, process flow, process structures, and applicable relationship between data structure and process standards.	Yes for both	1.485: Napier (1988a) provides the theoretical basis, control logic and flow, data flow and structure, mathematical models, process flow and structure, physical models, and coupling between structure and standards. 2.0: Napier (2002b) provides similar information. Pseudo-code listings are provided.
4.8	A Software Design Document, or equivalent, is available and contains a description of the allowable or prescribed ranges for inputs and outputs.	Yes for both	1.485: Napier (1988a) discusses ranges of input variables and error message generated when out of range. 2.0: Napier (2002b) provides similar information.
4.9	A Software Design Document, or equivalent, is available and contains the design described in a manner that can be translated into code.	Yes for both	1.485: Napier (1988a) and its appendix provide enough detail that the design can be translated into code 2.0: Napier (2002b) provides similar information. Pseudo-

Criterion Number	Criterion Specification	Met?	Summary Remarks
			code listings are provided.
4.10	A Software Design Document, or equivalent, is available and contains a description of the approach to be taken for intended test activities based on the requirements and design that specify the hardware and software configuration to be used during test execution.	Yes for both	1.485: Napier (1988a, b, c) discuss testing and the H/W and S/W configurations 2.0: Napier (1995, 2002b) provides similar information.
4.11	The organization responsible for the design identified and documented the particular verification methods to be used and assured that an Independent Review was performed and documented. This review evaluated the technical adequacy of the design approach; assured internal completeness, consistency, clarity, and correctness of the software design; and verified that the software design is traceable to the requirements.	Yes for 1.495. No for 2.0	1.485: Napier (1988a, b, c) states that the code has been thoroughly tested and verified by independent reviewers according to NQA-1 standards. 2.0: Because this code has not been completed in all its aspects, the final testing has not yet been done.
4.12	The organization responsible for the design assured that the test results adequately demonstrated the requirements were met.	Yes for 1.495. No for 2.0	1.485: Napier (1988a, b, c) states that the code has been thoroughly tested and verified by independent reviewers according to NQA-1 standards. 2.0: Because this code has not been completed in all its aspects, the final testing has not yet been done.
4.13	The Independent Review was performed by competent individual(s) other than those who developed and documented the original design, but who may have been from the same organization.	Yes for 1.495. No for 2.0	1.485: Napier (1988a, b, c) states that the code has been thoroughly tested and verified by independent reviewers according to NQA-1 standards. This includes review by competent, independent individuals. 2.0: Because this code has not been completed in all its aspects, the final testing has not yet been done.

Criterion Number	Criterion Specification	Met?	Summary Remarks
4.14	The results of the Independent Review are documented with the identification of the verifier indicated.	Yes for 1.495. No for 2.0	1.485: The independent reviewers are identified by name in the Acknowledgements section of Napier (1988a,b) 2.0: Because this code has not been completed in all its aspects, the final testing has not yet been done.
4.15	If review alone was not adequate to determine if requirements are met, alternate calculations were used, or tests were developed and integrated into the appropriate activities of the software development cycle.	N/A	N/A
4.16	Software design documentation was completed prior to finalizing the Independent Review.	Yes for both	1.485: Napier (1988a) states that the code has been thoroughly tested and verified by independent reviewers according to NQA-1 standards. This includes completion of S/W design prior to finalizing independent review. 2.0: Napier (2002b), the design document, has been completed. The final independent review has not yet occurred.

4.17	The extent of the Independent Review and the methods chosen are shown to be a function of the following:
	    The importance to safety
	    The complexity of the software
	    The degree of standardization
	    The similarity with previously proven software
		N/A	These issues are decided by the independent reviewers, not the code developers. Therefore they are not specifically addressed in the documentation of either version GENII.

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table:

> Criterion 4.1 — The Napier (1988a) appendix, *Hanford Environmental Dosimetry Upgrade Project (HEDUP) Task 02 - System Design Requirements*, is the complete SQA requirements document for GENII 1.485. It includes the following:

1. General computational requirements
2. Computational facilities, hardware, and databases
3. Code language
4. Coding Standard and coding standard tools
5. Input parameters and format:
   Release category and source term
   Scenarios
   Meteorology
   Environmental transport
   Exposure pathways
6. Dosimetry specifications
7. Risk assessment calculations
8. Integration of separate codes
9. Customized pathway requirements
10. Specialized scenario requirements
11. Output format
12. Graphics
13. Documentation and instructions
14. Error messages
15. Updates and revisions
16. Security
17. Quality assurance
18. Training

Napier (2002b) is the System Design Document for GENII 2.0. It defines details of the overall structure of the software, the major software components, their data file interfaces, and specific mathematical models to be used. The design represents a translation of the requirements (Napier, 1995) into a description of the software structure, software components, interfaces, and necessary data. The design focuses on the major components and data communication links that are key to the implementation of the software within the operating framework.

Criterion 4.5 — The error reporting forms for GENII 1.485 (see Figure 4-1) provided a formal method of problem mitigation. A similar methodology does not exist for GENII 2.0.

Criterion 4.10 — The hardware requirements for GENII 1.485 are an IBM PC/AT or compatible computer, an 80287 math coprocessor, 640 KB of random access memory, a minimum of 5 MB on-line disk storage, and operating under DOS 3.1 or later (Napier, 1988b). Hardware requirements for GENII 2.0 are Windows® 95, 98, NT, or 2000[4], using Pentium processors, and disk storage in excess of 60 MB. FRAMES and GENII make use of the memory swapping capabilities of Windows, so the programs should run on any Windows-compatible computer. However, they will generally run fastest on machines with 256Mbytes of memory or more (Napier, 2002a). GENII 2.0 will not run in the DOS environment.

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[4] The documentation from which this sentence was extracted (Napier, 2002a) was written before the advent of Windows XP. Experience shows that GENII 2.0 also runs under Windows XP.

Criterion 4.13 — GENII 1.485 has already been thoroughly reviewed and tested and there are no plans to pursue these issues again. GENII 2.0 has been reviewed at PNNL and several EPA clients, and it went through an advisory review with the EPA Science Advisory Board. This board suggested some additional capabilities that have not yet been implemented. The code author developed the code as general-purpose software and "importance to safety" was not an issue in its development. Standardization was an important consideration and was a direct response to the issue of testability and complexity of the older version. GENII 2.0 is very similar to 1.485 but it is not the same and is intended for a different set of users.

In summary, the GENII 1.485 User's Guide (Napier, 1988b), p 5.1, states: "The design process consisted of developing and internally testing software, developing test cases, and documenting software in accordance with the design input. The GENII package has been extensively tested and verified by hand, using the hand calculation worksheets of (the Code Maintenance Manual) and benchmarked against similar Hanford environmental dosimetry programs. A 10-volume set of test documentation is available for review from the authors upon request. The design process concluded with analysis of the final design by means of a Final Internal Development Review (FIDR). Two external peer reviews were held, as described in (the Conceptual Representation volume); these constitute the FIDR for the GENII package."

4.4.2   Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "Design," except for Item 12 (see Appendix B), and several e-mail communications with the code developer (Bruce Napier) have helped to clarify issues.

4.4.3   Software Quality-Related Issues or Concerns

There are no additional SQA related issues or concerns in "Design."

4.4.4   Other Areas for Improvement

No other areas of improvement have been identified.

4.4.5   Recommendations

Recommendations related to this topical area are provided in Table 4.4-2.

Table 4.4-2 — Recommendations for Design Phase Topic

Recom-mendation Number	Relates to Table 4.4-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
4.1	4.5	See recommendation 2.1 on criterion 2.6.		
4.2	4.11, 4.12, 4.13, 4.14	When GENII 2.0 is complete, a comprehensive independent review must be documented to cover all aspects of these items	Two FTE months	Four months

Additional Detail

No additional detail is needed on the above recommendations.

4.5   Topical Area 5 Assessment: Implementation Phase

This area corresponds to the requirement entitled *Implementation Phase* in Table 3-2 of the DOE SQA plan (DOE 2003e).

4.5.1   Criterion Specification and Result

This topical area is "graded" for GENII 1.485 and "required" for GENII 2.0. Table 4.5-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.5-1 — Subset of Criteria for Implementation Phase Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
5.1	The implementation process resulted in software products such as computer program listings and instructions for computer program use.	Yes for 1.485. Partial for 2.0	1.485: Napier (1988c) is the code maintenance manual, containing listings of all source code. Napier (1988b) is the user's manual. 2.0: Napier (2002a) is the user's guide. Program listings are not yet published.
5.2	Implemented software was analyzed to identify and correct errors.	Yes for 1.485. Partial for 2.0.	1.485: an error reporting and corrective action process was used during development. 2.0: used an informal error reporting process

Criterion Number	Criterion Specification	Met?	Summary Remarks
5.3	The source code finalized during verification (this phase) was placed under configuration control.	Yes for 1.485. No for 2.0.	1.485: Configuration control was in place during code development. Current configuration control is provided through RSICC, the distributor of the code, who will not release revised code unless tested and verified. 2.0: code is not yet finalized
5.4	Documentation during verification included a copy of the software, test case description, and associated criteria that are traceable to the software requirements and design documentation.	Yes for both	Although the documentation reviewed (Table 1-2) does not specifically address the items provided to the testers, the code author affirms that these items were given to them.

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table:
.

Criterion 5.1 — GENII 2.0 has not been finalized. Code listings should become available after completion and final testing of code.

Criterion 5.2 — See recommendation 2.1 (on Criterion 2.6) for a discussion of this.

Criterion 5.3 — The appendix to Napier (1988a), the system design document, states: "Configuration control shall be a feature of the software to protect the basic code from unauthorized changes. A control mechanism with sign-off procedures shall be implemented to protect the software from unauthorized modifications. Needed changes shall be validated before modification are permitted." Bruce Napier is the current custodian of GENII 1.485 although at times past others had been assigned this duty. The code is distributed through RSICC at Oak Ridge, TN. Together, they provide the current configuration control.

Criterion 5.4 — The code author (Bruce Napier) states (e-mail in Appendix A): "The test cases were generally designed to meet the needs of certain types of calculation, and were done first on the computer (using the code and documentation to run) and then again on the GENII-specific hand calculation worksheets. The criteria were that the numbers had to match to two significant figures (which is all that the GENII code transfers internally at certain steps)."

4.5.2   Sources and Method of Review

E-mails with the code author addressed some of these issues. In addition, all of the documentation listed in Table 1-2 was reviewed with attention to "Implementation," except for Item 12 (see Appendix B).

4.5.3   Software Quality-Related Issues or Concerns

There are no other SQA-related issues or concerns in "Implementation Phase."

4.5.4   Other Areas for Improvement

No other areas for improvement have been identified.

4.5.5   Recommendations

Recommendations related to this topical area are provide in Table 4.5-2.

Table 4.5-2 — Recommendations for Implementation Phase Topic

Recom-mendation Number	Relates to Table 4.5-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
5.1	5.1	Make GENII 2.0 code listings available upon completion and final testing of code.	One FTE week	One month

4.6   Topical Area 6 Assessment: Testing Phase

This area corresponds to the requirement entitled *Testing Phase* in Table 3-2 of the DOE SQA plan (DOE 2003e).

4.6.1   Criterion Specification and Result

This topical area is "required" for both GENII 1.485 and 2.0. Table 4.6-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.6-1 — Subset of Criteria for Testing Phase Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
6.1	The software was validated by executing test cases.	Yes for 1.485. No for 2.0.	1.485: code was validated by being thoroughly tested (Napier, 1988a, 1988b) 2.0: code not yet completed, so testing is not complete
6.2	Testing demonstrated the capability of the software to produce valid results for test cases encompassing the range of permitted usage defined by the program documentation. Such activities provide evidence to ensure that the software adequately and correctly performed all intended functions and does not perform adverse unintended functions.	Yes for 1.485. No for 2.0.	1.485: code was thoroughly tested (Napier, 1988a, 1988b) 2.0: code not yet completed, so testing is not complete
6.3	Testing demonstrated that the computer program properly handles abnormal conditions and events as well as credible failures appropriate warning or error messages are provided to the user when the code is used improperly (e.g., an input is specified outside acceptable range).	Yes for 1.485. No for 2.0.	1.485: code was thoroughly tested (Napier, 1988a, 1988b) 2.0: code not yet completed, so testing is not complete
6.4	Test Phase documentation includes test procedures or plans and the results of the execution of test cases. The test results documentation demonstrates successful completion of all test cases or the resolution of unsuccessful test cases and provides direct traceability between the test results and specified software requirements.	Yes for 1.485. No for 2.0.	1.485: code was thoroughly tested (Napier, 1988a, 1988b) 2.0: code not yet completed, so testing is not complete

Criterion Number	Criterion Specification	Met?	Summary Remarks
6.5	Test procedures or plans specify the following, <u>as applicable</u>: (1) Required tests and test sequence (2) Required range of input parameters (3) Identification of the stages at which testing is required (4) Requirements for testing logic branches (5) Requirements for hardware integration (6) Anticipated output values (7) Acceptance criteria (8) Reports, records, standard formatting, and conventions (9) Identification of operating environment, support software, software tools or system software, hardware operating system(s) and/or limitations	Yes for 1.485. No for 2.0.	1.485: code was thoroughly tested (Napier, 1988a, 1988b) 2.0: code not yet completed, so testing is not complete

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table:
.

> Criteria 6.1 – 6.5 — Napier (1988b) states that there is a ten-volume set of test documentation available for inspection by interested parties. These documents are not included in those reviewed here, as they are at the offices at PNNL. The GENII 2.0 User's Guide (Napier, 2002a), in reference to Version 1.485, states: "GENII Version 1 has been included in the International Atomic Energy Agency's VAMP project (VAlidation of Model Predictions - an acronym for the Coordinated Research Program on Validation of Models for the Transfer of Radionuclides in Terrestrial, Urban and Aquatic Environments), an international effort to compare environmental radionuclide transport models with measured environmental data. Results for test scenario CB (based on environmental measurements following the Chernobyl accident) indicated that dose estimates from GENII were comparable to, although slightly higher than, those of other participating models, which is consistent with its primary function as a prospective analysis tool. The models included in the code have been validated to various degrees by additional studies, however these have not been compared directly to output from the code."

4.6.2   Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "Testing Phase," except for Item 12 (see Appendix B).

4.6.3   Software Quality-Related Issues or Concerns

There are no other SQA-related issues or concerns in "Testing Phase."

4.6.4   Other Areas for Improvement

No other areas of improvement in the "Testing Phase" have been identified.

4.6.5   Recommendations

Recommendations related to this topical area are provide in Table 4.6-2.

Table 4.6-2 — Recommendations for Testing Phase Topic

Recom-mendation Number	Relates to Table 4.6-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
6.1	All	Document all testing of GENII 2.0.	Three FTE months	Six months

4.7   Topical Area 7 Assessment: User Instructions

This area corresponds to the requirement entitled *User Instructions* in Table 3-2 of the DOE SQA plan (DOE 2003e).

4.7.1   Criterion Specification and Result

This topical area is "required" for both GENII 1.485 and 2.0. Table 4.7-1 lists the subset of criteria reviewed for this topical area and summarizes the findings. Both versions of GENII are addressed (i.e., Versions 1.485 and 2.0).

Table 4.7-1 — Subset of Criteria for User Instructions Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
7.1	A description of the model is documented and made available to users.	Yes for both	1.485: Napier, 1988a 2.0: Napier, 2002b
7.2	User's manual or guide describes software and hardware limitations and identifies/includes approved operating	Yes for both	1.485: Napier, 1988b 2.0: Napier, 2002a Lahey Fortran-77 or F-99

Criterion Number	Criterion Specification	Met?	Summary Remarks
	systems (for cases where source code is provided, applicable compilers should be noted).		compiler used. Source code in: 1.485: Napier, 1988c 2.0: not provided
7.3	User's manual or guide includes description of the user's interaction with the software.	Yes for both	1.485: Napier, 1988b 2.0: Napier, 2002a and 2003
7.4	User's manual or guide includes a description of any required training necessary to use the software.	Yes for 1.485. No for 2.0.	1.485: A required training course is described in the system requirements document, not the user's manual. 2.0: Training is available (e.g., at EFCOG meetings) but it is not described in the User's Manual.
7.5	User's manual or guide includes input and output specifications.	Yes for both	1.485: Napier, 1988b 2.0: Napier, 2002a
7.6	User's manual or guide includes a description of user messages initiated because of improper input and how the user can respond.	Yes for both	1.485: Napier, 1988b 2.0: Napier, 2002a
7.7	User's manual or guide includes information for obtaining user and maintenance support.	Yes for 1.485. Partial for 2.0.	1.485: Readme.93 file on Distribution Disk 03 2.0: Napier, 2002a

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table:

> Criterion 7.2 — Both versions of GENII were written and compiled using the Lahey Fortran (F-77 or F-99) software, except for the user interface of GENII 1.485 (Apprentice), which was written using Microsoft QuickBasic. Source code for GENII 1.485 is given in Volume 3 of PNL-6584, *Code Maintenance Manual* (Napier, 1988c). It is also can be found on Distribution Disk02 by double clicking on SOURCE.EXE, which will unpack all the routines, both those in Fortran and those in QuickBasic. Source code is not provided for GENII 2.0.

> Criterion 7.4 — The appendix to Napier (1988a), the system requirements document, p A.15, states: "A short training program shall be developed at the completion of the code to instruct potential users on the execution of the code. A detailed stepwise instruction manual shall also be prepared. Training should consist of class sessions and hand-out instructions, with opportunity for hands-on testing of the code." This training was provided on GENII 1.485 after it was released but such training is no longer available. Training for GENII 2.0 has been available at annual EFCOG meetings but there is no guarantee this will continue. Training would be useful for GENII (either version). The

intuitive nature of the user interface and the documentation (e.g., Napier, 1988b, 2002a, 2003) is helpful but not enough for a first-time user.

Criterion 7.6 — In GENII 1.485, user input is primarily through the Apprentice program, which prompts the user for input and requires incorrect or incompatible entries to be corrected. Appendix B of the GENII 1.485 User's Manual (Napier, 1988b) gives an extensive discussion of error handling within GENII, not just that of Apprentice. For GENII 2.0, the FRAMES user interface provides error messages when input is incomplete, out of bounds, or conflicting. However, the current version has bugs. For example, it is possible to be trapped in an unending loop of error messages.

Criterion 7.7 — The GENII 1.485 User's Manual gives the names of the authors of GENII but not the contact information. The primary contact person is the lead author of the code, Bruce Napier (509-375-3916). In addition, RSICC has provided a "Readme" file with the name and telephone number of a very knowledgeable user of the code (Paul D. Rittman - 509-376-8715), who can also be contacted in case of problems. For GENII 2.0, the FRAMES Constituent Database user interface gives the contact information for the lead author of GENII (Bruce Napier).

4.7.2   Sources and Method of Review

The user's manual for GENII 1.485, *GENII – The Hanford Environmental Radiation Dosimetry Software System. Volume 2: User's Manual* (Napier, 1988b), was reviewed for this Gap Analysis. Section 2 of that document gives the code overview, including user interaction levels and data file descriptions. Section 3 gives specific user instructions for both user interaction levels 0 and 1. Section 4 discusses system requirements and Section 5 discusses quality assurance topics. Appendix A gives an input/output example and Appendix B gives an extensive discussion of error messages. A revision to some of the data files for GENII 1.485 was issued in 1993 and another in 1996, but these did not change the code or its usage.

The User's Guide for GENII 2.0, *GENII Version 2 User's Guide* (Napier, 2002a) and *Getting Started with GENII Version* 2 (Napier, 2003) were reviewed for this Gap Analysis. The User's Guide provides details on all the options available in GENII 2.0, whereas the Getting Started document provides an introduction useful for evaluating simple, but typical, scenarios.

Correspondence (e-mails and telephone conversations) with an expert user of GENII 2.0 and with Bruce Napier has also been reviewed. These are included as Appendix A of this document. The expert user of GENII 2.0 was identified by Bruce Napier as William Joyce[5], in whose opinion GENII 2.0 should not be used for DSAs. This was supported to some extent by the e-mails from Napier (see Appendix A).

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[5] Mr. Joyce is a Senior Safety Engineer with ATL International, Corp., 20010 Century Blvd, Suite 500, Germantown, MD 20874.

4.7.3   Software Quality-Related Issues or Concerns

An item not discussed in the documentation is memory management. GENII 1.485 was developed in the DOS environment and was expected to be run in that environment. Experience shows that it can be run in a DOS window in the Windows environment[6]. However, this has potential problems in that memory management is different between DOS and Windows and there is a possibility of problems arising in the Windows environment. This needs to be verified by an extensive comparison of results using an older computer that is DOS based with a newer computer that is Windows based.

The bug in error handling of GENII 2.0 (see Criterion 9.6) needs to be fixed.

4.7.4   Other Areas for Improvement

The GENII 2.0 user guidance (Napier, 2002b, 2003) doesn't always match the operations the user needs to perform. For example, in a number of cases, the instructions say to right-click a button whereas the correct procedure is a left-click. In addition, some of the screens the user sees are not in the same order given in the guidance.

GENII 1.485 can determine 95th percentile consequences in only one direction (sector) at a time. It would be very helpful to the analyst for GENII 1.485 to automatically determine the 95th percentile consequences in every sector at the site boundary and other user-selected distance (such as 100 m). This can be done now only by setting up multiple runs of GENII 1.485. GENII 2.0 cannot determine 95th percentile consequences except perhaps in a manner involving a random sampling of the weather and compiling statistics that would yield 95th percentile values. However, this has not yet been tested.

4.7.5   Recommendations

Recommendations related to this topical area are provide in Table 4.7-2.

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[6] The Radiation Safety Information Computational Center (RSICC) at Oak Ridge verified the performance of GENII 1.485 on a 486 PC under the MS DOS 6.2 and Windows 95 operating systems. Testing conducted during the preparation of this Gap Analysis shows that GENII 1.485 also can be executed in Windows 98SE and XP.

Table 4.7-2 — Recommendations for User Instructions Topic

Recom- mendation Number	Relates to Table 4.7-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
7.1	Criterion 7.2	Verify that GENII 1.485 runs correctly in a Windows environment (including XP)	One workday	One workday
7.2	Criterion 7.5	Correct the user guidance for GENII 2.0.	One FTE week	Two weeks
7.3	Criterion 7.6	The error message-handling problem needs to be fixed.	One FTE week	Two weeks

Additional Detail

Recommendation 7.1 – The estimate of one workday is for the comparison testing, which would consist of running the same scenarios side by side on DOS-based and Window-based computers. Should differences in results be found, use of GENII 1.485 would have to be restricted to only DOS-based computers.

4.8   Topical Area 8 Assessment: Acceptance Test

This area corresponds to the requirement entitled *Acceptance Test* Table 3-2 of the DOE SQA plan (DOE 2003e). During this phase of the software development, the software becomes part of a system incorporating applicable software components, hardware, and data, and is accepted for use. Much of this testing is the burden of the user organization, but the developing organization shoulders some responsibility.

4.8.1   Criterion Specification and Result

This topical area is "required" for both GENII 1.485 and 2.0. Table 4.8-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.8-1 — Subset of Criteria for Acceptance Test Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
8.1	To the extent applicable to the developer, acceptance testing includes a comprehensive test in the operating environment(s).	Yes for 1.485. No for 2.0.	1.485: Napier (1988b) states that the code was tested on PCs from many manufacturers. 2.0: acceptance testing is not yet complete but Napier (2002a) states but the test plan has been developed and testing underway
8.2	To the extent applicable to the developer, acceptance testing was performed prior to approval of the computer program for use.	Yes for 1.485. No for 2.0.	1.485: the code delivered to RSICC for distribution had been tested prior to release. 2.0: acceptance testing is not yet complete
8.3	The acceptance testing comprehensively evaluates software performance against specified software requirements. To the extent applicable to the developer, software validation was performed to ensure that the installed software product satisfies the specified software requirements.	Yes for 1.485. No for 2.0.	Both codes were developed under NQA-1 guidelines. This includes testing against software requirements. 1.485: acceptance testing complete and code in use. 2.0: acceptance testing is not yet complete
8.4	Acceptance testing documentation includes results of the execution of test cases for system installation and integration, user instructions (Refer to Requirement 7 above), and documentation of the acceptance of the software for operational use.	Yes for 1.485. No for 2.0.	1.485: extensive test documentation is available on all aspects of code development 2.0: acceptance testing is not yet complete

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table:

Criterion 8.1 — The GENII 1.485 User's Manual (Napier, 1988b), p 4.1, states: "Portions of the GENII Software Package have been tested on a number of IBM-PC/AT compatible machines. Versions of GENII have been established on microcomputers manufactured by GRID, NEC, Hewlett-Packard, and IBM. The IBM machines have included the new PS/2 System 50 and System 80. No machine-based incompatibilities have been found." The GENII 2.0 User Guide (Napier, 2002a), p 6, states: "A comprehensive test plan has been developed and testing is underway."

Criterion 8.2 — The preface to the RSICC distribution package of GENII 1.485 states that the authors of the code affirm that the code was tested prior to submission to RSICC for distribution to users.

Criterion 8.3 — The GENII 2.0 User Guide (Napier, 2002a), pp 5-6 states: "Both GENII versions were developed under QA plans based on the American National Standards Institute (ANSI) standard NQA-1 as implemented in the PNNL Quality Assurance Manual. All steps of the code development have been documented and tested, and hand calculations have verified the code's implementation of major transport and exposure pathways for a subset of the radionuclide library. A collection of hand calculations and other verification activities is available. A comprehensive test plan has been developed and testing is underway." The latter sentence refers to GENII 2.0, not 1.485.

Criterion 8.4 — Napier (1988b) states that there is a ten-volume set of test documentation available for inspection by interested parties.

4.8.2   Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "Acceptance Test," except for Item 12 (see Appendix B). The list in Appendix B includes a summary of developer/user testing and peer review of GENII for which documentation is available.

4.8.3   Software Quality-Related Issues or Concerns

There are no other SQA-related issues or concerns in "Acceptance Test."

4.8.4   Other Areas for Improvement

No other areas of improvement have been identified.

4.8.5   Recommendations

Recommendations related to this topical area are provide in Table 4.8-2.

Table 4.8-2 — Recommendations for Acceptance Test Topic

Recom- mendation Number	Relates to Table 4.8-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
8.1	All	Complete the documentation of acceptance testing for GENII 2.0	Two FTE months	Four months

4.9   Topical Area 9 Assessment: Configuration Control

This area corresponds to the requirement entitled *Configuration Control* in Table 3-2 of the DOE SQA plan (DOE 2003e).

4.9.1   Criterion Specification and Result

This topical area is "required" for both GENII 1.485 and 2.0. Table 4.9-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.9-1 — Subset of Criteria for Configuration Control Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
9.1	For the developers, the methods used to control, uniquely identify, describe, and document the configuration of each version or update of a computer program (for example, source, object, and back-up files) and its related documentation (for example, software design requirements, instructions for computer program use, test plans, and results) are described in implementing procedures.	Yes for both	1.485: Configuration control followed PNO-MA-70, the PNL version of the NQA-1 Quality Assurance Manual that existed during development. In addition, a series of "software change packets" have been maintained. 2.0: Formal procedures for configuration control follow the current PNNL "Software Based Management System" (SBMS). Notebooks and backups are also used for this purpose. (See Appendix A.)
9.2	Implementing procedures meet applicable criteria for configuration identification, change control, and configuration status accounting.	Yes for both	See the comments above, for Criterion 9.1.

Additional Detail

The following provides additional detailed explanation on selected criteria in the above table:

> Criteria 9.1 and 9.2 — Configuration control followed/follows procedures formalized in SQA methods used at PNL/PNNL during the development of each version of GENII. These procedures have evolved over the years, and thus, the procedures used for Version 2.0 are not identical to those used for Version 1.485. The author of the code(s) has kept informal notebooks and copies of earlier versions.

4.9.2   Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "Configuration Control," except for Item 12 (see Appendix B), as well as e-mails with the code developer.

4.9.3   Software Quality-Related Issues or Concerns

There are no SQA-related issues or concerns in "Configuration Control."

4.9.4   Other Areas for Improvement

No additional areas of improvement in "Configuration Control" have been identified.

4.9.5   Recommendations

There are no recommendations related to this topical area.

4.10   Topical Area 10 Assessment: Error Impact

This area corresponds to the requirement entitled *Error Impact* in Table 3-2 of the DOE SQA plan (DOE 2003e).

4.10.1   Criterion Specification and Result

This topical area is "graded" for both GENII 1.485 and 2.0. Table 4.10-1 lists the subset of criteria reviewed for this topical area and summarizes the findings.

Table 4.10-1 — Subset of Criteria for Error Impact Topic and Results

Criterion Number	Criterion Specification	Met?	Summary Remarks
10.1	The developing organization's problem reporting and corrective action process addresses the appropriate requirements of its corrective action system and is documented in implementing procedures.	Yes for 1.485. No for 2.0	Napier (1988b) discusses how to report errors and request upgrades. An informal method is used for GENII 2.0. See criterion 2.6.
10.2	The process for evaluating, and documenting whether a reported problem is an error is documented and implemented.	No for both	Not specifically discussed in the documentation reviewed. However, the SQA procedures followed during development

Criterion Number	Criterion Specification	Met?	Summary Remarks
			(see criterion 9.1) do require problem reporting and documenting.
10.3	The process for disposition of the problem reports, including notification to the originator of the results of the evaluation, is documented and implemented.	No for both	Not specifically discussed in the documentation reviewed. However, the SQA procedures followed during development (see Criterion 12.1) do require proper disposition of problem reports.
10.4	A documented process provides guidance on determining how identified errors relate to appropriate software engineering elements and is implemented.	No for both	Not discussed in the documentation reviewed.
10.5	The process is documented and implemented for determining how an error impacts past and present use of the computer program.	No for both	Not discussed in the documentation reviewed.
10.6	The process is documented and implemented for determining how an error and resulting corrective action impacts previous development activities.	No for both	Not discussed in the documentation reviewed.
10.7	The process is documented and implemented describing how the users are notified of an identified error, its impact; and how to avoid the error, pending implementation of corrective actions.	No for both	Not discussed in the documentation reviewed.

4.10.2 Sources and Method of Review

All of the documentation listed in Table 1-2 has been reviewed with attention to "Error Impact," except for Item 12 (see Appendix B).

4.10.3 Software Quality-Related Issues or Concerns

For users of GENII 2.0 within PNNL, the existing Standards Based Management System (SBMS) process can be followed. There would be no software quality-related issues or concerns for these users. However, for users outside of PNNL, the process of error notification and corrective action needs to be formalized and documented so that users know how to report errors,

how PNNL will respond, how PNNL will notify other users of the problem, and how too avoid the problem.

4.10.4 Other Areas for Improvement

No other areas of improvement are noted.

4.10.5 Recommendations

Recommendations related to this topical area are provide in Table 4.10-2.

Table 4.10-2 — Recommendations for Error Impact Topic

Recom-mendation Number	Relates to Table 4.13-1 Criterion Number(s)	Recommendation	Est. FTE to Complete	Est. Calendar Duration
10.1	All	A formal error reporting and corrective action process needs to be implemented for GENII 1.485 and GENII 2.0 for users outside of PNNL.	One FTE month	Two months

4.11 Training Program Assessment

No regularly scheduled GENII training program is conducted. Training materials for Version 1.485 of GENII are still available, but there have been no requests made to the author (Bruce Napier) to use these for several years.

There have been discussions with the EPA about training on Version 2, and the author has given some Version 2.0 training at recent EPA NESHAPS meetings (held annually). Future training may be provided to the NRC headquarters staff. However, the latter is still in the planning stage.

The last known training to DOE safety analysis community occurred during the 2000 Energy Facility Contractors Group (EFCOG) Safety Analysis Working Group Workshop (April 2000). It is recommended that this forum be explored to provide DOE users with a regular opportunity for GENII training.

5.0   Conclusion

The GENII code gap analysis has been completed. For GENII 1.485, of the ten applicable topical quality areas for software developers, nine met the criteria fully, and one failed to meet the criteria. GENII 1.485 should create and follow a formal error reporting and corrective action process. For GENII 2.0, of the same ten general topical quality areas, two met the criteria fully, five met the criteria partially, and three failed to meet the criteria.

Recommendations are given for each of the topical areas in Section 4.0. It is estimated that approximately ten full-time equivalent (FTE) months would be required to perform all SQA upgrade tasks covered in Section 4.0. Because GENII 1.485 has been in use for many years and the code developer does not intend to make any further modifications, no similar estimates need be made. The error-reporting estimate for GENII 2.0 may be applied to GENII 1.485. It would be useful for personnel at RSICC to respond to Recommendation 7.1 regarding running the code in the DOS and Windows environments. This is estimated to require only about one day. The GENII 1.485 documentation would not need to be changed but documentation of the results could be included with the RSICC distribution package for GENII 1.485.

Training opportunities exist for both versions of GENII, but these are not routinely offered. It is recommended that training at the annual EFCOG Safety Analysis Working Group Workshop be offered to familiarize DOE and DOE contractor personnel on the GENII software and applications.

The GENII code was evaluated to determine if the code, as it currently stands, meets the intended function for the code in the context as described in the scope of this gap analysis. When the code is run for the intended applications, as detailed in the code guidance document, *Computer Code Application Guidance for Documented Safety Analysis*, (DOE 2003f), it is judged that GENII 1.485 will meet its intended function, but GENII 2.0 will not. Therefore, only GENII 1.485 can be recommended for DSA use at this time.

While completion of the GENII 2.0 development is encouraged, current DOE DSA support should be through the earlier code version, GENII 1.485. No evidence was found of software-induced errors in GENII 1.485 that have led to non-conservatisms in nuclear facility operations or in the identification of facility controls.

6.0   Acronyms and Definitions

ACRONYMS

ANS	American Nuclear Society
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CD	Compliance Decision
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CSARP	Cooperative Severe Accident Research Program
DNFSB	Defense Nuclear Facilities Safety Board
DoD	Department of Defense
DOE	Department of Energy
DSA	Documented Safety Analysis
EFCOG	Energy Facility Contractors Group
IEEE	Institute of Electrical and Electronics Engineers
INEL	Idaho National Engineering Laboratory
IP	Implementation Plan
ISO	International Organization for Standardization
LPF	Leak Path Factor
MCAP	MELCOR Code Applications Program
MELCOR	Methods for Estimation of Leakages and Consequences of Releases (code)
NRC	Nuclear Regulatory Commission
QAP	Quality Assurance Program (alternatively, Plan)
RSICC	Radiation Safety Information Computational Center
SNL	Sandia National Laboratories
SQA	Software Quality Assurance
SRS	Savannah River Site
V&V	Verification and Validation
WSRC	Westinghouse Savannah River Company

DEFINITIONS

The following definitions are taken from the Implementation Plan. References in brackets following definitions indicate the original source, not the Implementation Plan.

Acceptance Testing	The process of exercising or evaluating a system or system component by manual or automated means to ensure that it satisfies the specified requirements and to identify differences between expected and actual results in the operating environment. [NQA-1]
Central Registry	An organization designated to be responsible for the storage, control, and long-term maintenance of the Department's safety analysis "toolbox codes." The central registry may also perform this function for other codes if the Department determines that this is appropriate.
Classification (Level of Software)	Determination of the level of SQA associated with a computer code commensurate with the importance of the software application. For the toolbox codes, classification level is determined as described in Appendix A of: "Software Quality Assurance Plan and Criteria for the Safety Analysis Toolbox Codes."
Commercial Grade Item	An item satisfying a), b), and c) below:

      (a)   Not subject to design or specification requirements that are unique to nuclear facilities.

      (b)   Used in applications other than nuclear facilities.

      (c)   Ordered from the manufacturer/supplier on the basis of specifications set forth in the manufacturer's published product description (for example, catalog). [IEEE Std. 7-4.3.2-1993]

Computer Code	A set of instructions that can be interpreted and acted upon by a programmable digital computer (also referred to as a module or a computer program).
Configuration Item	A collection of hardware or software elements treated as a unit for the purpose of configuration control. [NQA-1]
Configuration Management	The process that controls the activities, and interfaces, among design, construction, procurement, training, licensing, operations, and maintenance to ensure that the configuration of the facility is established, approved and maintained. (Software specific): The process of identifying and defining the configuration items in a system (i.e., software and hardware), controlling the release and change of these items throughout the system's life cycle, and recording and reporting the status of configuration items and change requests. [NQA-1]
Control Point	A point in the software life cycle at which specified agreements or control (typically a test or review) are applied to the software configuration items being developed, e.g., an approved baseline or release of a specified document or computer program. [NQA-1]
Commercial Grade Dedication	A process of evaluating (which includes testing) and accepting commercial grade items to obtain adequate confidence of their

	suitability for safety application. [IEEE Std. 7-4.3.2-1993]
Data Library	A data file for use with an executable code that is created and maintained by the controlling organization and is not intended for modification by the user.
Dedication (of Software)	The evaluation of software not developed under utilizing organization existing quality assurance plans and procedures (or not developed under NQA-1 standards). The evaluation determines and asserts the software's compliance with NQA-1 quality standards and its readiness for use in specific applications. (Typically applies to commercially available software.) The utilizing organization reviews the intended software application sufficiently to determine the critical functions that provide evidence of the software's suitability for use. Once the critical functions have been established, methods are defined to verify critical function adequacy and provide verifiable acceptance criteria. Acceptable dedication methods are implemented and required documentation is prepared.
Design Requirements	Description of the methodology, assumptions, functional requirements, and technical requirements for a software system.
Discrepancy	The failure of software to perform according to its documentation.
Error	A condition deviating from an established base line, including deviations from the current approved computer program and its baseline requirements. [NQA-1]
Executable Code	The user form of a computer code. For programs written in a compilable programming language, the compiled and loaded program. For programs written in an interpretable programming language, the source code.
Firmware	The combination of a hardware device and computer instructions and data that reside as read-only software on that device. [IEEE Standard 610.12-1990]
Gap Analysis	Evaluation of the SQA attributes of specific computer software against identified criteria.
Independent Verification and Validation (IV&V)	Verification and validation performed by an organization that is technically, managerially, and financially independent of the development organization.
Nuclear Facility	A reactor or a nonreactor nuclear facility where an activity is conducted for, or on behalf of, DOE and includes any related area, structure, facility, or activity to the extent necessary to ensure proper implementation of the requirements established by 10 CFR 830. [10 CFR 830]
Object Code	A computer code in its compiled form. This applies only to programs written in a compilable programming language.
Operating Environment	A collection of software, firmware, and hardware elements that provide for the execution of computer programs. [NQA-1]

Safety Analysis and Design Software	Computer software that is not part of a Structure, System, or Component (SSC) but is used in the safety classification, design, and analysis of nuclear facilities to ensure proper accident analysis of nuclear facilities; proper analysis and design of safety SSCs; and proper identification, maintenance, and operation of safety SSCs.
Safety Analysis Software Group (SASG)	A group of technical experts formed by the Deputy Secretary in October 2000 in response to Technical Report 25 issued by the DNFSB. This group was responsible for determining if the safety analysis and Instrument and Control (I&C) software needs to be fixed or replaced, establishing plans and cost estimates for remedial work, providing recommendations for permanent storage of the software and coordinating with the Nuclear Regulatory Commission on code assessment, as appropriate.
Safety-Class Structures, Systems, and Components (SC SSCs)	SSCs, including portions of process systems, whose preventive and mitigative function is necessary to limit radioactive hazardous material exposure to the public, as determined from the safety analyses. [10 CFR 830]
Safety-Significant Structures, Systems, and Components (SS SSCs)	SSCs, which are not designated as Safety-Class (SC) SSCs, but whose preventive or mitigative function is a major contributor to defense in depth and/or worker safety as determined from safety analyses. [10 CFR 830] As a general rule of thumb, Safety Significant (SS) SSC designations based on worker safety are limited to those SSCs whose failure is estimated to result in prompt worker fatalities, serious injuries, or significant radiological or chemical exposure to workers. The term, serious injuries, as used in this definition, refers to medical treatment for immediately life-threatening or permanently disabling injuries (e.g., loss of eye or loss of limb). The general rule of thumb cited above is neither an evaluation guideline nor a quantitative criterion. It represents a lower threshold of concern for which an SS SSC designation may be warranted. Estimates of worker consequences for the purpose of SS SSC designation are not intended to require detailed analytical modeling. Consideration should be based on engineering judgment of possible effects and the potential added value of SS SSC designation. [DOE G 420.1-1]
Safety Software	Includes both safety system software and safety analysis and design software.
Safety Structures, Systems, and Components (SSCs)	The set of SC SSCs and SS SSCs for a given facility. [10 CFR 830]
Safety System Software	Computer software and firmware that performs a safety system function as part of a SSC that has been functionally classified as SC or SS. This also includes computer software such as human-machine interface software, network interface software, programmable logic controller (PLC) programming language software, and safety management databases that are not part of an SSC but whose operation or malfunction can directly affect SS and SC SSC function.

Sample Input	Input data for a designated sample problem that is maintained by the controlling organization for distribution to users.
Software	Computer programs, operating systems, procedures, and possibly associated documentation and data pertaining to the operation of a computer system. [IEEE Std. 610.12-1990]
Software Design Verification	The process of determining if the product of the software design activity fulfills the software design requirements. [NQA-1]
Software Development Cycle	The activities that begin with the decision to develop a software product and end when the software is delivered. The software development cycle typically includes the following activities: (a) Software design requirements (b) Software design (c) Implementation (d) Test And sometimes: (e) Installation. [NQA-1]
Software Engineering	The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software; also: the study of these applications. [NQA-1]
Software Life Cycle	The activities that comprise the evolution of software from conception to retirement. The software life cycle typically includes the software development cycle and the activities associated with operation, maintenance, and retirement. [NQA-1]
Source Code	A computer code in its originally coded form, typically in text file format. For programs written in a compilable programming language, the uncompiled program.
System Software	Software designed to enable the operation and maintenance of a computer system and its associated computer programs. [NQA-1]
Test Case	A set of test inputs, execution conditions, and expected results developed for a particular objective, such as to exercise a particular program path or to verify compliance with a specific requirement. [NQA-1]
Test Case Input	Input data for a test case used to verify a modification to a module or a data library.
Test Plan (Procedure)	A document that describes the approach to be followed for testing a system or component. Typical contents identify the items to be tested, tasks to be performed, and responsibilities for the testing activities. [NQA-1]
Testing	An element of verification for the determination of the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental, or operating conditions. [NQA-1]

Testing (Software)	The process of
	(a) Operating a system (i.e., software and hardware) or system component under specified conditions.
	(b) Observing and recording the results.
	(c) Making an evaluation of some aspect of the system (i.e., software and hardware) or system component, in order to verify that it satisfies specified requirements and to identify errors. [NQA-1]
Toolbox Codes	A small number of standard computer models (codes) supporting DOE safety analysis, having widespread use, and meeting minimum qualification standards. These codes are sufficiently verified and validated, and may be said to constitute a "safe harbor" methodology. That is to say, the analysts using these codes do not need to present additional defense as to their qualification, if they are sufficiently qualified to use the codes and the input parameters are valid.
User Manual	A document that presents the information necessary to employ a system or component to obtain desired results. Typically described are system or component capabilities, limitations, options, permitted inputs, expected outputs, possible error messages, and special instructions. Note: A user manual is distinguished from an operator manual when a distinction is made between those who operate a computer system (mounting tapes, etc.) and those who use the system for its intended purpose. Syn: User Guide. [IEEE 610-12]
Validation	1) The process of testing a computer program and evaluating the results to ensure compliance with specified requirements. [ANSI/ANS-10.4-1987]
	2) The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model. [Department of Defense Directive 5000.59, DoD Modeling and Simulation (M&S) Management]
Verification	1) The process of evaluating the products of a software development phase to provide assurance that they meet the requirements defined for them by the previous phase. [ANSI/ANS-10.4-1987]
	2) The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. [Department of Defense Directive 5000.59, DoD Modeling and Simulation (M&S) Management]

7.0   References

CFR Code of Federal Regulations (10 CFR 830). 10 CFR 830, Nuclear Safety Management Rule.

DNFSB Defense Nuclear Facilities Safety Board, (2000). *Quality Assurance for Safety-Related Software at Department of Energy Defense Nuclear Facilities*, Technical Report DNFSB/TECH-25, (January 2000).

DNFSB Defense Nuclear Facilities Safety Board, (2002). *Recommendation 2002-1, Quality Assurance for Safety-Related Software,* (September 2002).

DOE, U.S. Department of Energy (2000a). *Appendix A, Evaluation Guideline,* DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Reports* (January 2000).

DOE, U.S. Department of Energy (2000b). *Quality Assurance for Safety-Related Software at Department of Energy Defense Nuclear Facilities*, DOE Response to TECH-25, Letter and Report, (October 2000).

DOE, U.S. Department of Energy (2002). *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Reports*, DOE-HDBK-3010-94, Change Notice 2 (April 2002).

DOE, U.S. Department of Energy (2003a). *Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2002-1: Quality Assurance for Safety Software at Department of Energy Nuclear Facilities*, Report, (March 13, 2003).

DOE, U.S. Department of Energy (2003b). *Designation of Initial Safety Analysis Toolbox Codes*, Letter, (March 28, 2003).

DOE, U.S. Department of Energy (2003c). *Assessment Criteria and Guidelines for Determining the Adequacy of Software Used in the Safety Analysis and Design of Defense Nuclear Facilities*, Report, CRAD-4.2.4-1, Rev 0, (August 27 2003).

DOE, U.S. Department of Energy (2003d). *Software Quality Assurance Improvement Plan: Format and Content For Code Guidance Reports*, Revision A (draft), Report, (August 2003).

DOE, U.S. Department of Energy (2003e). *Software Quality Assurance Plan and Criteria for the Safety Analysis Toolbox Codes*, (draft), Report, (September 2003).

DOE, U.S. Department of Energy (2003f). MACCS2 Computer Code Application Guidance for Documented Safety Analysis, (draft), Report, (September 2003).

Napier, 1988a, B. A. Napier, R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, *GENII – The Hanford Environmental Radiation Dosimetry Software System. Volume 1: Conceptual Representation.* PNL-6584, Pacific Northwest Laboratories, Richland, WA, (December 1988).

Napier, 1988b, B. A. Napier, R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, *GENII – The Hanford Environmental Radiation Dosimetry Software System. Volume 2: User's Manual*, PNL-6584, Pacific Northwest Laboratories, Richland, WA, (November 1988).

Napier, 1988c, B. A. Napier, R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, *GENII – The Hanford Environmental Radiation Dosimetry Software System. Volume 3: Code Maintenance Manual*, PNL-6584, Pacific Northwest Laboratories, Richland, WA, (September 1988).

Napier, 1995, B. A. Napier, J. V. Ramsdell, and D. L. Strenge. *Software Requirements Specifications for Hanford Environmental Dosimetry Coordination Project*, May 1995 Draft Report, prepared for review by the EPA Office of Radiation and Indoor Air.

Napier, 1999a, B. A. Napier, *GENII Version 2 Example Calculation Descriptions*, Prepared for U.S. Environmental Protection Agency, January 1999.

Napier, 1999b, B. A. Napier and L. Staven, *GENII Version 2 Training Power Point Slides*, Presented at the Safety Analysis Workshop of the annual meeting of the Energy Facility Contractors Group (EFCOG), June 1999.

Napier, 2002a, B. A. Napier, *GENII Version 2 User's Guide*, Prepared for U.S. Environmental Protection Agency, September 2002.

Napier, 2002b, B. A. Napier, D.L. Strenge, J. V. Ramsdell, Jr., P. W. Eslinger, and C. Fosmire, *GENII Version 2 Software Design Document*, Prepared for U.S. Environmental Protection Agency, November 2002.

Napier, 2003, B. A. Napier, *Getting Started with GENII Version 2*, Prepared for U.S. Environmental Protection Agency, February 2003.

Napier, 2003, B. A. Napier, Communication with K.R. O'Kula.

Appendices

Appendix	Subject
A	COMMUNICATIONS WITH OTHERS
B	GENII BENCHMARKING AND V&V

APPENDIX A.— COMMUNICATIONS WITH OTHERS

E-mails

From: O'Kula, Kevin [mailto:Kevin.OKula@WXSMS.com]
Sent: Friday, September 19, 2003 4:42 PM
To: Joyce, William
Subject: Urgent Need for GENII Version 2 Guidance Document

William E. Joyce
Senior Safety Engineer
ATL International, Corp
20010 Century Blvd, Suite 500
Germantown, MD 20874

Mr. Joyce:

I work for Westinghouse Safety Management Solutions in Aiken, SC, and am supporting DOE in
the area of SQA.

(deleted material not relevant to the gap analysis)

Bruce Napier recommended you as the most expert GENII Version 2 user he was aware of.
Would you be interested in providing a rough draft of a guidance document?
…
Let me know at your earliest convenience.

Kevin O'Kula
Westinghouse Safety Management Solutions LLC
P. O. Box 5388
Aiken, SC 29804-5388
Phone: 803.502.9620
Fax: 803.502.9773
FEDX: 2131 South Centennial Avenue, Bldg. #3
Aiken, South Carolina 29803

From: O'Kula, Kevin [mailto:Kevin.OKula@WXSMS.com]
Sent: Thursday, September 25, 2003 11:19 AM
To: Napier, Bruce A
Subject: FW: Urgent Need for GENII Version 2 Guidance Document

Bruce:

I spoke at length with William yesterday.

He discussed his current work with GENII Version 2.0 for Dose Reconstruction, where he stated that the annual average conditions were being used. He strongly recommended that we not endorse it for accident analysis applications. Among other reasons, he said that the new version does not allow a 95th percentile X/Q based dose to be determined for acute (~1 hour) releases. Is this accurate?

We have seen more use of the "older" version, 1.485. For example, the ANL people are using it for the MOX EIS for both routine and accident releases. We asked them why they weren't using the new version, and they indicated that the NRC wanted them to apply 1.485. Could they have done this work for accident releases and found the 95th percentile dose with GENII Version 2.0?

Thanks,

Kevin

From: Napier, Bruce A [mailto:Bruce.Napier@pnl.gov]
Sent: Friday, September 26, 2003 6:07 AM
To: O'Kula, Kevin
Subject: HA: Urgent Need for GENII Version 2 Guidance Document

Version 2 is much different than 1.485.
We use hourly meteorology, not joint frequency data.
I have it set up for the acute release met model to start at a defined date and time. HOWEVER, the FRAMES system has a stochastic processor that wraps around all the GENII modules and allows variation in all the input parameters - and I have the date/time set up to input as Julian[7] hour. This means that I can actually run the whole thing a few thousand times, varying the start time. This has the effect of building the entire output dose distribution, not just the 95th percentile meteorology. This is a much different way of doing it than we have done before. The problem comes with the lack of completed testing - I am still quite skeptical that this is all working correctly. So I don't recommend it yet, either.

ALSO - since I never saw anybody use it, I have taken out the Winter/Spring/Summer/Fall output, and only use the Fall model. I suppose that I could put it all back in - but would you use it?

Bruce

Following a request from Jim Rhone for review of the SQA Plan and Criteria for the Safety Analysis Toolbox Codes Report, Napier sent this reply:

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[7] By Julian hour, he means the number of hours since the beginning of the year, although this is not the correct use of this term.

From: Napier, Bruce A [mailto:Bruce.Napier@pnl.gov]
Sent: Tuesday, October 21, 2003 6:18 PM
To: Jim Rhone
Cc: Kevin.okula@wxsms.com; Eng, Tony
Subject: RE: GENII Code Developer Review

Hi guys;

I'm back from a few weeks of relative isolation in Siberia (and I must say, it is more comfortable there, where the email doesn't work and the phone doesn't either).

I'm trying to catch up with your needs…

I'm not looking forward to this.

I think that I should respond "twice" to your paperwork. Once for GENII 1.485 and once for GENII Version 2.0. They are sufficiently dissimilar that I think that we would be misleading people if we tried to do them together. So that you know what I'm thinking:

GENII 1.485 was developed under the earliest NQA-1 standards (1986 version):
• SQA Plan
      got one, out of date. Refers to PNNL manual no longer available, but I have the key chapters.
• Software Requirements Document
      got one, but the one we developed was VERY SHORT, and not nearly as detailed as the system now wants.
• Software Design Document
      I would say that the GENII PNL-6854 Volume 1 report covers this
• Test Case Description and Report
      We have a series of regression tests that we know the answers to, and ran all modifications against. We also have an extensive series of documented hand calculation worksheets that give "the right answer." This isn't in the format of a "report" - but I have several file cabinets full of the tests
• Software Configuration and Control Document
       This is also not in the format of a "document." We have hard copies of all the versions from 1.350 (the point at which we thought things were stable) through 1.485, including the "Software change packets." I have let RSICC do my distribution for years.

• Error Notification and Corrective Action Report
       We no longer do this, except in extraordinary circumstances (like last year's H3 debacle at Savannah River), when we tell RSICC and they tell the world.
• User's Manual, and other relevant documentation (model description, weekly or monthly reports to code sponsor, etc.).
       I think that GENII PNL-6854 Volume 2 report covers this

So that you understand: DOE quit funding any GENII support or maintenance in the early
1990's. I have lost the capability to make changes to the compiled Basic APPRENTICE routines
(and I'd be afraid to mess with the Fortran routines, too, because I don't think that my old
compiler will run on a recent machine, and I certainly don't want to try to change to a new one,
because the code was so specific to the Lahey F77 compiler.) THERFORE, there have been NO
official changes to the code since 1990.

GENII Version 2 keeps the name, and a few of the basic algorithms. Pretty much everything else
is new.
This has been held up in the "development" phase for years because of lack of money to get it
completed. I inch it along when I have personal time to do so.
The formal QA is weaker than for 1.485, in part because we are using the lab's "Good Practices"
standards instead of NQA-1:

• SQA Plan
      got one, it's pretty short. It also refers to lab manuals, but at least these exist!
• Software Requirements Document
      got one, reasonably detailed and complete
• Software Design Document
      GENII Version 2 Software Design Document available
• Test Case Description and Report
      Since it isn't done, we don't have one of these.
• Software Configuration and Control Document
       all I've got is my notebooks and backups.

• Error Notification and Corrective Action Report
       I only have a few beta users; they let me know when it's broke and I fix it for them.
• User's Manual, and other relevant documentation (model description, weekly or monthly
reports to code sponsor, etc.).
       GENII Version 2 Users Guide available, plus the "Getting Started with GENII" instructions
that keep getting longer and longer...

HOWEVER: the whole thing was reviewed by the EPA Science Advisory Board (who have a
report), and EPA paid some people to go over it this year. I have NOT seen the results of this
review; I have no idea what they said or who did it. I am a tad disappointed that they spent the
money and then didn't even bother to tell me the results.

Bruce

P.S. I don't think that I have any comments on the SQA Plan and Requirements (other than a
couple of really minor typos).

From: VERN PETERSON [mailto:vlrep@msn.com]
Sent: Monday, January 05, 2004 3:27 PM

To: Napier, Bruce A
Subject: more questions

Bruce,

...

Here is another requirement I must assess for the gap analysis: "Documentation during
verification included a copy of the software, test case description, and associated criteria that are
traceable to the software requirements and design documentation." I don't know how to answer
this but you probably do. When the independent reviewers/testers did verification of the code,
did they have all these things mentioned? I assume they did but I can't find a statement to this
effect in the 1.485 or 2.0 documentation. (It may be there but if so, I missed it.)

…

Vern Peterson

From: Napier, Bruce A
To: Vern Peterson
Sent: Tuesday, January 06, 2004 12:59 PM
Subject: RE: more questions

The test cases were generally designed to meet the needs of certain types of calculation, and were
done first on the computer (using the code and documentation to run) and then again on the
GENII-specific hand calculation worksheets. The criteria were that the numbers had to match to
2 significant figures (which is all that the GENII code transfers internally at certain steps).

So: YES they had the software.
       YES they had the documentation. The GENII documentation, PNL-6584 Volume 1
contains the Design Requirements as an appendix. So YES, it's traceable.
       YES they had test case descriptions (or wrote their own).
       YES they had criteria.

Telephone conversations

Conversation between William Joyce and Vern Peterson, October 14, 2003

These are highlights from the conversation:
- ?   GENII 2.0 is not appropriate for DSAs because it can't give 95th percentile consequences
  and because the JDF files developed at Hanford are not appropriate for DSA work – they
  don't meet DOE requirements (but new ones could be constructed that do meet DOE
  requirements)

- ? The ten receptor locations in GENII 2.0 are each forced to be at the nearest grid points, which may not be where the user wants them
- ? GENII 2.0 is meant for EPA NESHAPS, not DOE DSAs
- ? GENII 1.485 was developed in a DOS environment and therefore had to address the memory limit of <640 KB. The Windows memory management system is different and there is a potential that this may lead to problems.
- ? Neither GENII 1.485 nor GENII 2.0 are appropriate for DSA work, in his opinion.

APPENDIX B. — GENII BENCHMARKING AND V&V
(List provided by Bruce Napier)

Publications on GENII Verification and Validation

Johnson, K.A., and M.J. Sowa. 1997. <u>Benchmarking the GENII and RESRAD Computer Codes,</u> Oregon State University Radiation Center, Corvallis, Oregon.

International Atomic Energy Agency. 1995. <u>Validation of Models using Chernobyl Fallout Data from the Central Bohemia Region of the Czech Republic: Scenario CB</u>, IAEA-TECDOC-795, First Report of the VAMP Multiple Pathways Assessment Working Group, International Atomic Energy Agency, Vienna, Austria.

Maheras, S.J. 1995. *GENII Version 1.485* (Software Review), <u>Health Physics, 68</u>, pp. 119-121.

Rittmann, P.D. 1995. <u>Benchmarking of Computer Codes (GENII, PATHRAE, RESRAD) Using Hand Calculations</u>, Westinghouse Hanford Company, Richland, Washington.

Maheras, S.J., P.D. Ritter, P.R. Leonard, and R. Moore. *Benchmarking of the CAP-88 and GENII Computer Codes using 1990 and 1991 Monitored Atmospheric Releases from the Idaho National Engineering Laboratory*, <u>Health Physics, 67</u>, pp. 509-517.

Faillace, E.R., J.J. Cheng, and C. Yu. 1994. <u>RESRAD Benchmarking Against Six Radiation Exposure Pathway Models</u>, ANL/EAD/TM-24, Argonne National Laboratory, Argonne, Illinois.

Preece, A.B. 1993. <u>Use of the GENII Computer Code in a Low-Level Radioactive Waste Disposal Facility Performance Assessment Methodology</u>. Master's Thesis, University of Texas, Austin, Texas.

Seitz, R.R., J.R. Cook, M.I. Wood, P.D. Rittmann, B.A. Napier, and D.W. Wood. 1992. <u>Comparison of Computer Codes and Inputs Used at DOE Sites to Model Intrusion Scenarios</u>, PNL-SA-20502, Pacific Northwest Laboratory. Presented at Waste Management '92, Tucson, Arizona, March 1-5, 1992

Kozak, M.W., M.S.Y. Chu, and P.A. Mattingly. 1990. A Performance Assessment Methodology for Low-Level Waste Facilities, NUREG/CR-5532, Sandia National Laboratories, Albuquerque, New Mexico.

Kozak, M.W., M.S.Y. Chu, P.A. Mattingly, J.D. Johnson, and J.T. McCord. 1990. Background Information for the Development of a Low-Level Waste Performance Assessment Methodology: Identification and Recommendation of Computer Codes, NUREG/CR-5453, Volume 5, Sandia National Laboratories, Albuquerque, New Mexico.

Jaquish, R. E., and B. A. Napier. 1987. "A Comparison of Environmental Radionuclide Concentrations Calculated by a Mathematical Model with Measured Concentrations." PNL-SA-

14720. In <u>Proceedings of ANS Topical Conference on Population Exposure from the Nuclear Fuel Cycle</u>. Oak Ridge, Tennessee.

Aaberg, R. L., and B. A. Napier. 1985. <u>Hanford Dose Overview Program: Comparison of AIRDOS-EPA and Hanford Site Dose Codes</u>, PNL-5633, Pacific Northwest Laboratory, Richland, Washington.

Additional GENII Benchmarking and Comparisons

Stull, E. 1990. Comparison of GENII and RSAC-4 for use in the New Production Reactor EIS program.

Ikenberry, T.A. 1990. Demonstration of acceptable accuracy and reproducibility of the HUDU atmospheric dispersion and radiation dose program (benchmark against GENII).

Peterson, V., R. Patlovany, and G. Ennis. 1992. Comparison of MACCS and GENII, EG&G Rocky Flats, Boulder, Colorado.

Sartori, E., A. Curti, L. Riposi, and G. Graziani. 1992. Comparison of GENII and VADOSCA Computer Codes. Nuclear Energy Agency, Commission of the European Communities.

Abbott, M. 1993. MACCS2 benchmarking against GENII, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

Aaberg, R.L. 1993. Comparison of GENII and RSAC-5 for the Tank Waste Remediation System (TWRS). Pacific Northwest National Laboratory, Richland, Washington.

Morris, J., and C. Williams. 1994. Workshop to discuss the use of environmental transport and fate models in the Environmental Restoration part of the DOE Programmatic Environmental Impact Statement (PEIS).

Peer Review of Multimedia Models. 1994. Comparison of MEPAS, MMSOIL, RESRAD, and GENII. M. Small (Carnegie-Mellon), D. Back (HydroGeologic), R. Charbeneau (U. Texas), C. Chein (duPont), Y. Cohen (U. California), T. Gallagher (HydroQual), M. Kavanaugh (Montgomery Watson), J. Mauro (SC&A), E. Makhlouf (Montgomery Watson), and B. Weiss (U. Rochester).

Seitz, R., P.D. Rittmann, J. Cook, and M. Wood. 1994. Comparison of PATHRAE and GENII, DOE Performance Assessment Task Team.

Summary of Developer/User Testing and Peer Review of GENII for which Documentation is Available

Baker, D. 1987. Review of HEDUP documentation and QA.

Carter, M.(Georgia Institute of Technology), K. Eckerman (Oak Ridge National Laboratory), J. Johnson (Chalk River Laboratory). 1987. External peer review panel.
R.Gray. 1988. Extramural panel review of GENII.

Napier, B.A. 1990. GENII "Conversion Testing, Verification, and Validation of Software" plan listing 42 tests performed as of 2/7/1989.

Rhoads, K. 1990. Review of acute dispersion calculation GENII Version 1.449.

Winter, R., G. Anast, H. Avci, M. Biggerston, D. Smith. 1990. Informal review of GENII verification and validation. Argonne National Laboratory/ DOE-HQ.

Nelson, I.C., L.H. Sawyer, T.A. Ikenberry. 1990. Hand Calculations performed on GENII to support NPR-EIS program.

Sawyer, L.H., T.A. Ikenberry. 1991. Hand calculations performed to support acute models in GENII.

Cammann, J. and P.D. Rittmann. 1990. Revisions to GENII dose increment libraries.

Peloquin, R.A., 1994. GENII Hand Calculation Worksheets, version of February 2, 1994.